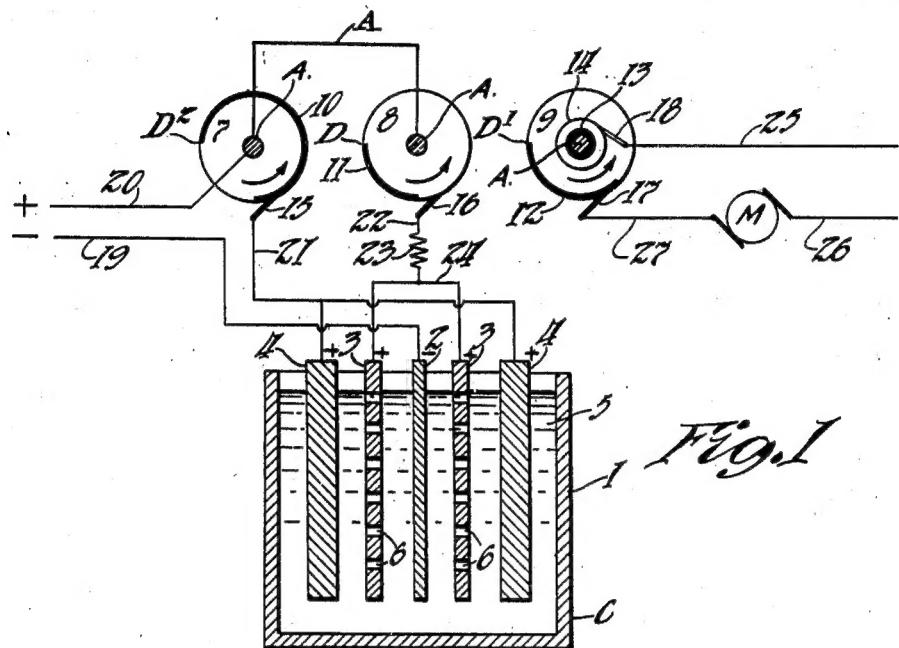


T. A. EDISON.
PRODUCTION OF THIN METALLIC SHEETS OR FOILS.
APPLICATION FILED OCT. 4, 1919.

1,379,089.

Patented May 24, 1921.



UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF LLEWELLYN PARK, WEST ORANGE, NEW JERSEY.

PRODUCTION OF THIN METALLIC SHEETS OR FOILS.

1,379,089.

Specification of Letters Patent. Patented May 24, 1921.

Application filed October 4, 1919. Serial No. 328,378.

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, a citizen of the United States, and a resident of Llewellyn Park, in the town of West Orange, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in the Production of Thin Metallic Sheets or Foils, of which the following is a description.

10 My invention relates to the production of very thin metallic sheets or foils and more particularly to the production of thin nickel sheets designed to be used in making nickel flakes for storage batteries of the alkaline type; and the invention resides in an improved process especially adapted for making such sheets or foils and also in an electroplating system and an electrolytic cell employed in carrying out such process.

20 In Letters Patent No. 865,687 and No. 865,688 granted September 10, 1907, and No. 936,525, granted October 12, 1909, I describe processes of making metallic films or flakes intended particularly for use in storage batteries of the alkaline type, and consisting generally in electroplating upon a suitable cathode thin and alternate layers or films of a readily soluble metal, such as copper, and of the desired metal, such as nickel, or cobalt or cobalt-nickel alloy. The composite sheet thus formed is removed from the cathode and cut into small portions which are then treated with suitable reagents, in which copper is soluble, but which do not affect the nickel or cobalt.

35 In apparatus at present used for carrying out the processes described in the aforesaid patents, a plurality of revolving cathode drums mounted on a traveling crane are first respectively and simultaneously lowered into the electrolyte of a plurality of electro-plating cells containing a copper solution and copper anodes, where exceedingly thin layers or films of copper are plated 40 onto the drums. The cathode drums are then raised out of the copper-plating cells and the crane is advanced to a washing tank where the cathodes are washed, preferably by spraying water thereon, to remove the 45 films of the copper-plating solution which cling thereto. The crane is then advanced to a position in which the drums are respectively disposed above a plurality of electro-plating cells containing nickel anodes and 50 nickel solutions, and the drums lowered into said cells and allowed to remain therein 55

until layers or coatings of nickel, each about .0005" in thickness, are plated thereon. The drums are then raised from the nickel-plating cells and the crane moved to the washing tank where the cathode drums are washed, preferably by sprays of water, to remove the films of the nickel-plating solution which cling thereto. The above cycle of operations is repeated until the desired 60 number (usually 250) of alternate layers of copper and nickel have been plated on the cathode drums, the composite sheets then being stripped or removed from the cathode drums and cut up into very small pieces, 65 generally about $\frac{1}{16}$ " square, which are treated with a suitable reagent to dissolve the copper and produce the desired thin nickel flakes.

The present invention renders the use of 75 traveling cranes, washing tanks and different plating cells for plating the copper and nickel in the production of the alternate layers of copper and nickel, as described above, unnecessary, and is based on the 80 discovery that alternate thin layers or films of copper and nickel, in a condition which answers all the requirements necessary for the making of nickel flakes such as are used in alkaline storage batteries, may under certain 85 conditions, be plated on a cathode from a single electrolytic bath. Practically the only labor necessary in producing composite sheets of copper and nickel in accordance with my invention, is to remove the same 90 from the cathodes after they have been formed on the latter by plating the desired number of alternate layers of copper and nickel.

More particularly described, my invention 95 consists in employing an electrolytic cell or cells each of which comprises a composite plating bath consisting of a mixture of a strong nickel-plating solution, preferably a substantially saturated solution of 100 nickel sulfate, and a copper-plating solution, preferably a substantially saturated solution of copper sulfate, and in which the nickel-plating solution greatly predominates. The bath also preferably contains a 105 salt of a fatty acid, preferably acetate of nickel, for a purpose which will be herein-after described. While the proportions of the materials in the bath may be varied considerably, I preferably employ these materials in the following proportions: Three 110 hundred parts by weight of the saturated so-

lution of nickel sulfate, three parts by weight of the saturated solution of copper sulfate, and eighteen parts by weight of solid acetate of nickel. Disposed in the bath of each cell 5 are a single cathode and two anodes, one of nickel and one of copper. A current of density less than that which will deposit nickel is first passed through the cell in a path which includes only the cathode, the electrolyte 10 and the copper anode. During the passage of this current through the cell no deposit of copper will appear on the cathode for a considerable period of time providing there is no agitation of the electrolyte. If 15 the electrolyte is vigorously agitated during this period, however, a thin layer of copper will be deposited on the cathode so as to completely cover the latter. This is due to the fact that the agitation of the electrolyte 20 hastens the electrolytic action of the current on the copper solution and effects circulation of the electrolyte and therefore causes practically all of the copper freed from this solution, to gather in the vicinity of the cathode. Accordingly, as soon as the circuit 25 is established through the cell so as to include the copper anode as described, I agitate the electrolyte and continue the agitation thereof for the greater part of the period 30 allowed for the deposition of copper and then maintain the electrolyte quiet during the remainder of such period, preferably for about one-sixth thereof. During this time when the electrolyte is maintained quiet 35 practically all of the remaining copper in the solution adjacent the cathode will be deposited on the latter and the solution therefore practically exhausted of copper. The plating circuit through the copper anode, 40 the electrolyte and the cathode is then broken and another circuit established in a path which includes the nickel anode, the electrolyte and the cathode, through which a current of high density is passed. A coating 45 of nickel of the desired thickness, namely, about .0005", will now be plated on the cathode in a comparatively short time, and this nickel will be practically free from copper, the amount of copper deposited with 50 the nickel being so very small as not to effect the brightness and smoothness of the nickel deposited. This would not be the case if the copper were not practically exhausted from the solution adjacent the cathode and if the 55 solution contained such an amount of copper, that copper would immediately be deposited without agitation of the electrolyte upon the establishment of the depositing circuit through the copper anode, electrolyte 60 and cathode. The circuit through the nickel anode, electrolyte and cathode is now broken, and the cycle of operations above described is repeated until the desired number 65 of alternate layers of copper and nickel are plated onto the cathode. The composite

sheet formed on the cathode may then be removed and treated as hereinbefore described to obtain thin films or flakes of nickel. The cathode employed in my improved cell is preferably formed of copper and previous 70 to the mounting thereof in the cell, is preferably provided with an extremely thin surface layer or film of selenide of copper in order to facilitate the stripping or removal of the composite sheet plated thereon, as 75 described in my pending application Serial No. 308,821 filed June 21, 1919, and entitled Electro-plating.

The densities of the copper-plating and nickel-plating currents may be varied considerably as may also the time for performing the complete cycle of depositing one layer of copper and one layer of nickel, the division of this time into periods respectively employed for plating a single layer 85 of copper and a single layer of nickel, and the portions of the period employed for the deposition of a layer of copper during which the electrolyte is agitated and maintained quiet. Preferably I employ a copper-plating current, having a density just below that which will effect deposition of nickel, and a nickel-plating current having a density about twenty-five times that of the copper-plating current. 95

The presence of the acetate of nickel in the electrolyte effects the deposition of substantially pure, malleable nickel on the cathode when the path of the plating current is through the nickel anode, electrolyte and the cathode, as described in my pending application Serial No. 324,291 filed September 18, 1919, and entitled Production of nickel. 100

In order that my invention may be more clearly understood, attention is directed to the drawing accompanying and forming a part of this specification and in which:—

Figure 1 is a diagrammatic view, partly in section, of an electrolytic plating system in accordance with my invention, the agitator 110 for the cell shown being omitted;

Fig. 2 is a plan view of the cell shown in Fig. 1 and one form of means for agitating the electrolyte of the cell; and

Fig. 3 is a sectional view taken on line 115 3—3 of Fig. 2.

Referring to the drawing, reference character C represents one form of electroplating cell in accordance with my invention, consisting of a suitable container 1, a cathode 2, a pair of copper anodes 3, 3 respectively disposed closely adjacent and at either side of the cathode 2, and a pair of nickel anodes 4, 4 respectively disposed at either side of the cathode 2 and beyond the copper anodes 125 3, 3. The cathode 2, copper anodes 3, 3 and nickel anodes 4, 4 may be supported in the electrolyte 5 of the cell in any suitable manner. Each of the copper anodes 3 is provided with numerous perforations 6 extend- 130

ing therethrough for purposes which will presently be described.

The circuits of the depositing currents through the cell C and the circuit of a motor M for actuating the means for effecting agitation of the electrolyte, are preferably automatically controlled by any suitable commutating device. As shown in the drawing, this commutating device comprises a shaft 10 A of conducting material driven at a slow and constant speed from any suitable source of power, such as a finely regulated electric motor (not shown), three commutator disks 15 7, 8 and 9 mounted on the shaft A to rotate therewith and brushes coöperating with said disks. The disks 7, 8 and 9 are respectively provided with peripheral portions 10, 11 and 12 of insulating material, the remainder of these disks being formed of conducting material. Each of the disks 7 and 8 is grounded to the shaft A, and these disks are therefore in electrical connection, this connection being represented on the drawing by conductor A'; while the disk 9 is insulated from said shaft and therefore from the disks 7 and 8 as by means of a sleeve 13, formed of any suitable non-conducting material, surrounding the shaft and extending through the disk 9 and the hub 14 thereof. Brushes 15, 16 and 17 respectively bear on the peripheries of the disks 7, 8 and 9, and a brush 18 bears on the periphery of the hub 14 of the disk 9. Conductors 19 and 20 leading from any suitable source (not shown), are respectively directly connected to the cathode 2 and the shaft A. The brush 15 is electrically connected by means of a conductor 21 and branches leading from the latter to the nickel anodes 4, 4. The brush 40 16 is connected by a conductor 22 to one terminal of a suitable resistance 23, the other terminal of the resistance being connected by a conductor 24 and branches leading from the latter, to the copper anodes 3, 3. Reference characters 25 and 26 represent conductors leading from any suitable source (not shown), for supplying current to the agitator motor M. The brushes 17 and 18 are included in the motor circuit, being respectively directly connected to the conductor 25 and to a branch 27 of the latter which leads to one of the motor brushes. The shaft A is constantly driven in the direction indicated by the arrows in Fig. 1, at such a rate 50 as to make one complete rotation during the period allowed for performing the complete cycle of electroplating one layer of copper and one layer of nickel on the cathode 2. Preferably, the insulation 10 extends three-fourths the way around the periphery of disk 7, the insulation 11 extends around that fourth of the periphery of disk 8 corresponding to the portion of the periphery of disk 7 not formed of insulation, and the insulation 12, starting at a point D' in the pe-

riphery of disk 9 corresponding to the point D where the insulation 11 on disk 8 begins and to the point D² where the insulation 10 on disk 7 ends (with reference to the direction indicated by the arrows) extends three-eighths of the way around the periphery of disk 9. The conductor 20 will therefore be electrically connected to conductor 21 through the shaft A, disk 7 and brush 15, during one-fourth of the period of each rotation of shaft A, and during the remaining three-fourths of the period of each rotation of shaft A, the conductor 20 will be electrically connected to conductor 22 through shaft A, disk 8 and brush 16. Conductor 25 75 will also be electrically connected to the branch conductor 27 through brushes 17 and 18 and disk 9, during the five-eighths of the period of each rotation of shaft A, equal to the first five-sixths of the period of connection of conductor 20 to brush 16 through shaft A and disk 8.

The motor M may actuate any suitable means for agitating the electrolyte in the cell C during the first and major part of 90 the time of the passage of the copper depositing current through the cell. As shown, however, the agitating means comprises a U-shaped frame 30 extending lengthwise and across the top of the cell and having its legs slidably mounted in suitable bearings 31 secured to the top edges of the end walls of the cell container 1. The legs of the frame 30 respectively carry a plurality of spaced agitator bars 32 depending therefrom and extending into the electrolyte of the cell between the cathode 2 and the copper anodes 3. A pitman 33 is pivotally connected at one end to the base 34 of the U-shaped frame 30 and at its other end to a crank pin 35 carried by a disk 36. The disk 36 is mounted on a shaft 37 which is driven by suitable reducing gearing, such as a worm 38 and worm wheel 39, from the motor M.

During the period in each cycle when the conductor 20 is electrically connected to conductor 22, a copper plating current will pass through the cell in the following path: from the source of current through the conductor 20, shaft A, disk 8, brush 16, conductor 22, resistance 23, conductor 24, to the copper anodes 3, 3, then through the electrolyte 5, cathode 2 and conductor 19 back to the source. During the first five-sixths of this period, the circuit of the agitator motor M will also be closed, the path of this circuit being as follows: from the source of current through the conductor 25, brush 18, disk 9, brush 17, branch conductor 27, through the motor to the conductor 26 and back to the source. When the circuit of motor M is thus closed, the motor will, of course, effect reciprocation of the frame 30 and thereby agitation of the electrolyte. The resistance 23 130

is such that the copper plating current passing through the cell will be of a density just below that which is sufficient to plate nickel. This current is also insufficient in density to effect the plating of copper on the cathode for a considerable period, provided the electrolyte is maintained quiet. However, due to the agitation of the electrolyte during the first and major part of the period allowed 5 for plating copper, as just described, a thin film of copper is deposited on the cathode. Moreover, at the end of this period the electrolyte adjacent the cathode will be practically exhausted of copper, as described 10 above. During the period in each cycle, when the conductor 20 is electrically connected to conductor 21, a nickel plating current of comparatively high density will pass through the cell in the following path: from 15 the source of current through conductor 20, shaft A, disk 7, brush 15, conductor 21, to the nickel anodes 4, 4, then through the electrolyte 5, cathode 2 and conductor 19 back to the source. During this period a 20 film or coating of nickel substantially .0005 inch in thickness will be deposited on the cathode 2, as described above. The operation of the system is continued until the desired number of alternate layers of copper 25 and nickel are plated onto the cathode. The composite sheet thus formed is then removed or stripped from the cathode and cut into pieces of the desired size, which are suitably treated to dissolve out the copper and 30 produce the thin nickel flakes, as above described.

The copper anodes 3, 3 are of such quality and made of such size and surface area as to be nearly one hundred percent efficient, 40 whereby the percentage of copper in the electrolyte is maintained substantially constant for a long period. The provision of the perforations 6 in the copper anodes 3, 3 increases the effective surface area of these 45 anodes and also facilitates the circulation of the electrolyte and therefore the action of the cell during the plating of both the copper and the nickel.

It is to be understood that my invention is 50 subject to numerous modifications and is limited only as defined by the terms of the appended claims.

Having now described my invention, what I claim and desire to protect by Letters 55 Patent is as follows:—

1. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, 60 and two anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode,

which current has a density less than that which will deposit metal of which the other anode is composed, then breaking the circuit of said current and passing a current of comparatively high density through the cell in a path including said other anode, the electrolyte and the cathode, substantially as described. 70

2. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing 75 solutions of a salt of each of such metals, and two anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode, which current has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte during the passage of said current through 80 the cell, then breaking the circuit of said current and passing a current of comparatively high density through the cell in a path including said other anode, the electrolyte and the cathode, substantially as described. 85

3. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, and two 95 anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode, which current 100 has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte for only a part of the period during which said current is passed through the cell, then breaking the 105 circuit of said current and passing a current of comparatively high density through the cell in a path including said other anode, the electrolyte and the cathode, substantially as described. 110

4. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, and two 115 anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode, which current has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte for the first and greater part of the period during which said current is passed through the cell and maintaining the electrolyte quiet 120 during the remainder of said period, then breaking the circuit of said current and passing a current of comparatively high 125

density through the cell in a path including said other anode, the electrolyte and the cathode, substantially as described.

5. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, and two anodes respectively formed of such metals and a cathode disposed in said bath, 10 which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode, which current has a density less than that which will deposit metal of which the other anode is composed, then breaking the circuit of said current and passing a current of comparatively high density through the cell in a path including said other anode, the electrolyte and the cathode, then breaking 15 the circuit of said last mentioned current, and repeating the foregoing steps until the desired number of alternate layers of said two metals are plated on the cathode, substantially as described.

25. 6. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, and two anodes respectively formed of such 30 metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the cathode, which current has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte during the passage of said current through the cell, then breaking the circuit of said 35 current and passing a current of comparatively high density through the cell in a path including said other anode, the electrolyte and the cathode, then breaking the circuit of said last mentioned current, and repeating the foregoing steps until the desired 40 number of alternate layers of said two metals are plated on the cathode, substantially as described.

45. 7. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, and two anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through 50 the cell in a path including one of said anodes, the electrolyte and the cathode, which current has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte for only a part of the period during which 55 said current is passed through the cell, breaking the circuit of said current and then passing a current of comparatively high density through the cell in a path in-

cluding said other anode, the electrolyte and 65 the cathode, then breaking the circuit of said last mentioned current, and repeating the foregoing steps until the desired number of alternate layers of said two metals are plated on the cathode, substantially as described. 70

8. The process of electro-plating alternate layers of two different metals in an electrolytic cell comprising a bath containing solutions of a salt of each of such metals, 75 and two anodes respectively formed of such metals and a cathode disposed in said bath, which consists in passing a current through the cell in a path including one of said anodes, the electrolyte and the 80 cathode, which current has a density less than that which will deposit metal of which the other anode is composed, agitating the electrolyte for the first and greater part of the period during which said current is 85 passed through the cell and maintaining the electrolyte quiet during the remainder of said period, then breaking the circuit of said current and passing a current of comparatively high density through the cell in a 90 path including said other anode, the electrolyte and the cathode, then breaking the circuit of said last mentioned current, and repeating the foregoing steps until the desired number of alternate layers of said two 95 metals are plated on the cathode, substantially as described.

9. In an electro-plating system, an electrolytic cell comprising a bath containing 100 solutions of salts of two metals to be plated, two anodes respectively formed of said two metals and a cathode disposed in said bath, and means for alternately effecting passage of current through said cell in two paths respectively including one of said anodes, 105 the electrolyte and the cathode and the other of said anodes, the electrolyte and the cathode, substantially as described.

10. In an electro-plating system, an electrolytic cell comprising a bath containing solutions of salts of two metals to be plated, two anodes respectively formed of said two metals and a cathode disposed in said bath, and means automatically operative to effect passage of current through said cell alternately in two paths respectively including one of said anodes, the electrolyte and the cathode and the other of said anodes, the electrolyte and the cathode, substantially as described. 110

11. In an electro-plating system, an electrolytic cell comprising a bath containing solutions of salts of two metals to be plated, two anodes respectively formed of said two metals and a cathode disposed in said bath, means automatically operative to effect passage of current through said cell alternately in two paths respectively including one 115 120 125

of said anodes, the electrolyte and the cathode and the other of said anodes, the electrolyte and the cathode, and means whereby the electrolyte is agitated during 5 only a part of the period of each passage of current through the cell in the path including one of said anodes, substantially as described.

12. In an electro-plating system, an electrolytic cell comprising a bath containing 10 solutions of salts of two metals to be plated, two anodes respectively formed of said two metals and a cathode disposed in said bath, means automatically operative to effect passage of current through said cell alternately 15 in two paths respectively including one of said anodes, the electrolyte and the cathode and the other of said anodes, the electrolyte and the cathode, and means whereby 20 the electrolyte is agitated during only the first and greater portion of the period of the passage of current through the cell in the path including one of said anodes, substantially as described.

13. In an electro-plating system, an electrolytic cell comprising a bath containing 25 solutions of a copper salt and a nickel salt, two anodes respectively formed of copper and nickel and a cathode disposed in said 30 bath, the bath being weak in the solution of the copper salt and comparatively strong in the solution of the nickel salt, and means for alternately effecting the passage of a current of low density through the cell in a path 35 including the copper anode, the electrolyte and the cathode and the passage of a current of comparatively high density through the cell in a path including the nickel anode, the electrolyte and the cathode, substantially 40 as described.

14. In an electro-plating system, an electrolytic cell comprising a bath containing 45 solutions of a copper salt and a nickel salt, two anodes respectively formed of copper and nickel and a cathode disposed in said bath, the bath being weak in the solution of the copper salt and comparatively strong in the solution of the nickel salt, and means for alternately effecting the passage of a 50 current of a density less than that which will deposit nickel through the cell in a path including the copper anode, the electrolyte and the cathode and the passage of a current of comparatively high density 55 through the cell in a path including the nickel anode, the electrolyte and the cathode, substantially as described.

15. In an electro-plating system, an electrolytic cell comprising a bath containing 60 solutions of a copper salt and a nickel salt, two anodes respectively formed of copper and nickel and a cathode disposed in said bath, the bath being weak in the solution of the copper salt and comparatively strong in the solution of the nickel salt, means for 65

alternately effecting the passage of a current through the cell in a circuit including the copper anode, the electrolyte and the cathode, said current being of such low density that unless the electrolyte is agitated, 70 no copper will be plated on the cathode for a considerable period after said circuit is made, and the passage of a current of comparatively high density through the cell in a path including the nickel anode, the electrolyte and the cathode, and means whereby the electrolyte is agitated during each passage of the current of low density through the cell, substantially as described.

16. In an electro-plating system, an electrolytic cell comprising a bath containing 75 solutions of a copper salt and a nickel salt, two anodes respectively formed of copper and nickel and a cathode disposed in said bath, the bath being weak in the solution of the copper salt and comparatively strong in the solution of the nickel salt, means for alternately effecting the passage of a current through the cell in a circuit including the copper anode, the electrolyte and the cathode, said current being of such low density that unless the electrolyte is agitated, 80 no copper will be plated on the cathode for a considerable period after said circuit is made, and the passage of a current of comparatively high density through the cell in a path including the nickel anode, the electrolyte and the cathode, and means whereby the electrolyte is agitated during each portion of the period of each passage of the current of low density through the cell, substantially as described.

17. An electrolytic cell consisting of a bath comprising a mixture of a copper-plating solution and a nickel-plating solution, and a cathode, a copper anode and a nickel anode disposed in said bath, substantially as described.

18. An electrolytic cell consisting of an electrolyte comprising a mixture of a nickel-plating solution and a copper-plating solution and in which the nickel-plating solution greatly predominates, and a cathode, a nickel anode and a copper anode disposed in said bath, substantially as described.

19. An electrolytic cell consisting of a bath comprising a mixture of a substantially saturated solution of nickel sulfate and a substantially saturated solution of copper sulfate substantially in the proportion of three hundred parts by weight of nickel sulfate and three parts by weight of copper sulfate, and a cathode, a nickel anode and a copper anode disposed in said bath, substantially as described.

20. An electrolytic cell consisting of a bath comprising a mixture of a nickel-plating solution and a copper-plating solution and in which the nickel-plating solution greatly predominates, said bath also contain-

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ing a salt of a fatty acid, and a cathode, a nickel anode and a copper anode disposed in said bath, substantially as described.

21. An electrolytic cell consisting of a bath comprising a mixture of a substantially saturated solution of nickel sulfate and a substantially saturated solution of copper sulfate in the proportion of substantially three hundred parts by weight of nickel sulfate to three parts by weight of copper sulfate, said bath also containing substantially eighteen parts by weight of acetate of nickel, and a cathode, a nickel anode and a copper anode disposed in said bath, substantially as described.

22. In an electro-plating system, an electrolytic cell comprising a bath containing solutions of salts of two metals to be plated, and two anodes respectively formed of said two metals and a cathode disposed in said bath, and means automatically operative to effect passage of current through said cell alternately in two paths respectively including one of said anodes, the electrolyte and the cathode and the other of said anodes, the electrolyte and the cathode, and to effect agitation of the electrolyte during each passage of current through the cell in the path including one of said anodes, substantially as described.

23. In an electro-plating system, an electrolytic cell comprising a bath containing a copper-plating solution and a nickel-plating solution, and a copper anode, a nickel anode and a cathode disposed in said bath, and means automatically operative to effect passage of current through said cell alternately

in two paths respectively including the copper anode, the electrolyte and the cathode and the nickel anode, the electrolyte and the cathode, and to effect agitation of the electrolyte during each passage of current through the cell in the path including the copper anode, substantially as described.

24. An electrolytic cell consisting of a bath containing solutions of salts of two metals to be plated, and two anodes respectively formed of said two metals and a cathode disposed in said bath, one of said anodes being disposed between the other anode and the cathode and being provided with perforations extending therethrough, substantially as described.

25. An electrolytic cell consisting of a bath comprising a mixture of a copper-plating solution and a nickel-plating solution in which the nickel-plating solution greatly predominates, and a cathode, a nickel anode and a copper anode disposed in said bath, said copper anode being provided with perforations extending therethrough, substantially as described.

26. An electrolytic cell consisting of a bath comprising a mixture of a nickel-plating solution and a copper-plating solution, and a cathode, a nickel anode and a copper anode disposed in said bath, said copper anode being disposed between the nickel anode and the cathode and being provided with perforations extending therethrough, substantially as described.

This specification signed this 30th day of September, 1919.

THOS. A. EDISON.